Research Program

Brendan Casey

DOE Annual Program Review

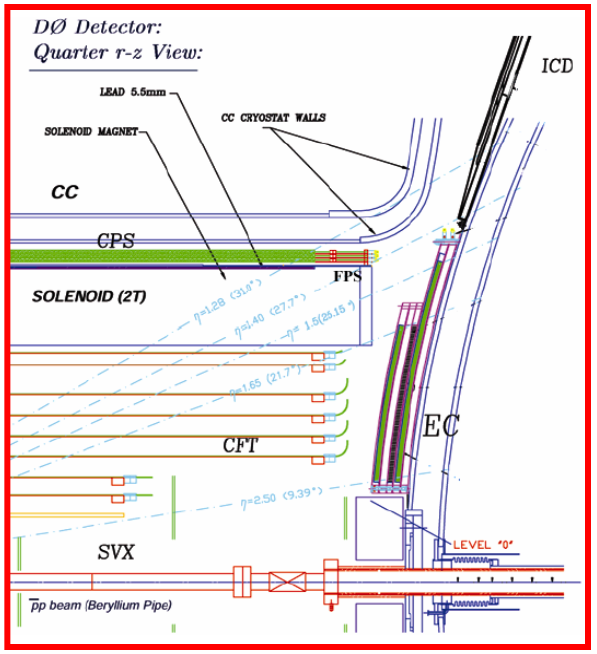
September 24-27 2007

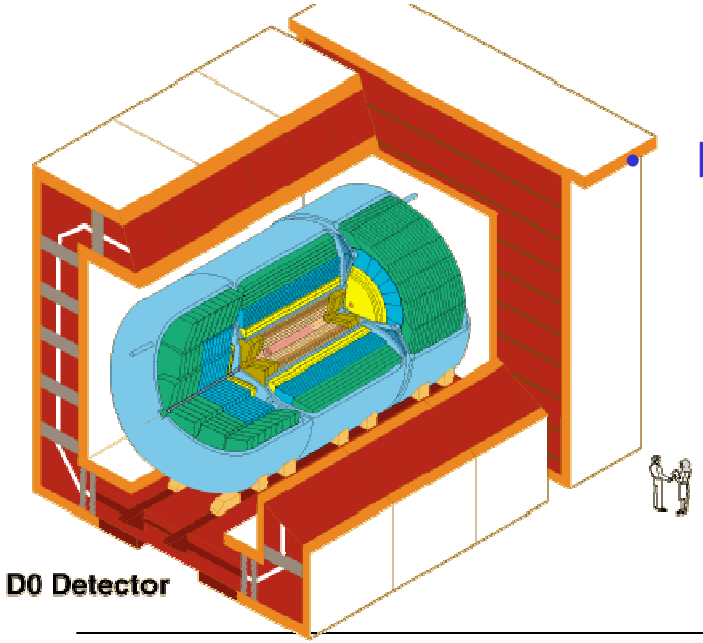
Physics Goals

- Better understanding of the fundamental dynamics that govern the early universe
  - Precision measurements of the properties and interactions of Standard Model quanta
    - Heavy quarks, gauge bosons
  - Understanding of Electroweak symmetry breaking and physics beyond the Standard Model
    - Direct searches for SM Higgs or more exotic phenomena (SUSY, extra dimensions, new strong dynamics…)
    - Searching for anomalies in the properties and interactions of SM quanta (couplings, mixing, CP violation…)

DØ Detector

- Based on the above physics goals, focus on
  - Lepton identification
  - Jets and missing transverse energy
  - Heavy flavor identification





Features

- Inner spectrometer w 2T solenoid
  - Silicon ($|\eta|<3$), scintillating fiber ($|\eta|< 1.5$)
- Central and forward preshowers
- LAr/U calorimetry ($|\eta| < 4.2$)
- Muon spectrometer w 1.8 T Toroid ($|\eta| < 2$)

DØ Collaboration

Fermilab DØ Group

- 53 members + support from PPD/CD divisions
- Leadership in all branches of collaboration
  - Upper management:
    - Spokesperson (D. Denisov), Physics Coordinator (A. Juste), Operations (G. Ginther), Computing/Algorithms (A. Boehnlein)
- Active in all aspects of enabling the physics program
  - See talk by Qizhong Li in collider experiment breakout session
- Producing results in all areas of the physics program
  - See talk by Herb Greenlee in same breakout session

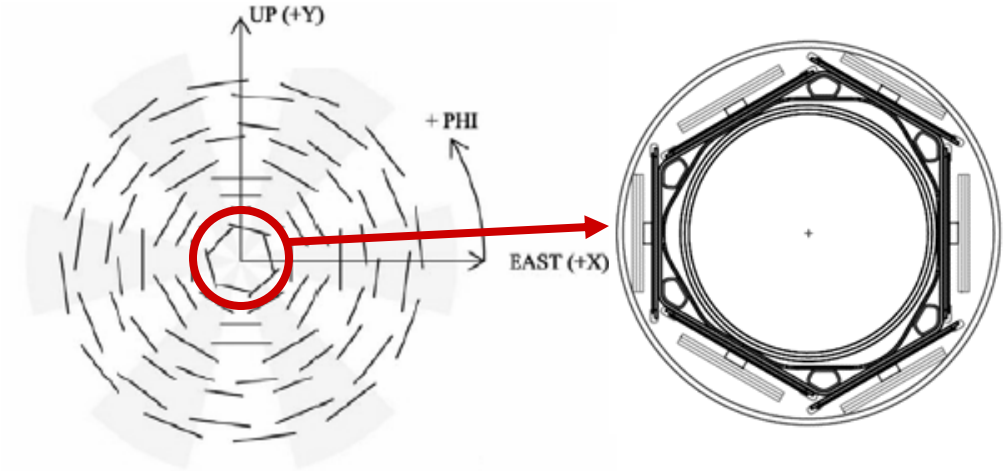
FNAL DØ Scientists

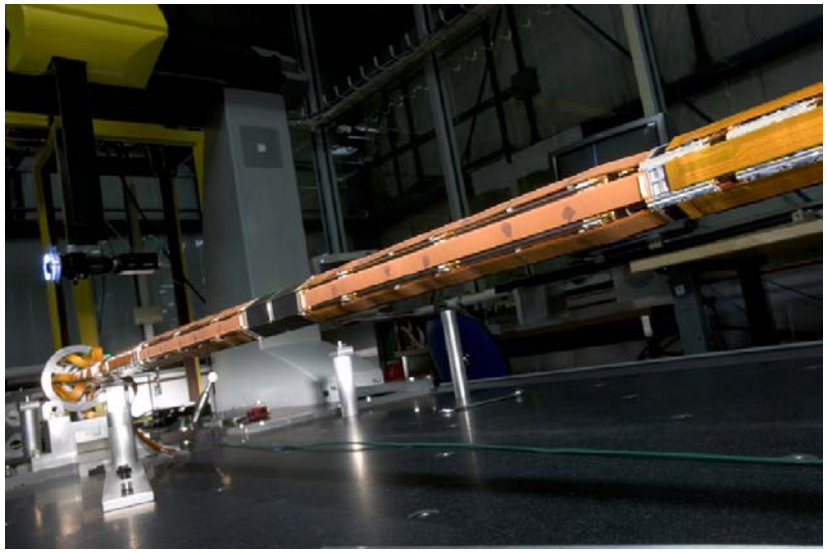
- ~23 FTE Scientists in the DØ Group
- Currently about 8 post docs, 1 Letterman Fellow, 2 Wilson Fellows
- Materials budget in support of the group is ~$200k
  - Plan is to maintain a constant level throughout the run
- More details on DØ Experiment Operations costs, Guests and Visitors are available from the Operations Review.

Highlights since last program review

- DØ published 200th paper:
  - Discovery of the Ξ_b^- **baryon: PRL 99, 052001 (2007)**
- **Major milestone reached in finding first evidence for single top production**
- Rapid integration of Silicon, Calorimeter and tracking triggers, and fiber tracker readout upgrades
  - 1.1 fb^{-1} recorded and 87% data taking efficiency in FY07
  - Doubled the data on tape in 14 months
- Rapid turn around of physics results
  - First 2 fb^{-1} result shown at Moriond ($B_s \to \mu\mu$) **~5 weeks after data written to tape**
  - **40 new results for Lepton-Photon conference in August 2007, most based on data taken up to May 2007**

Silicon Upgrade (Layer Ø)





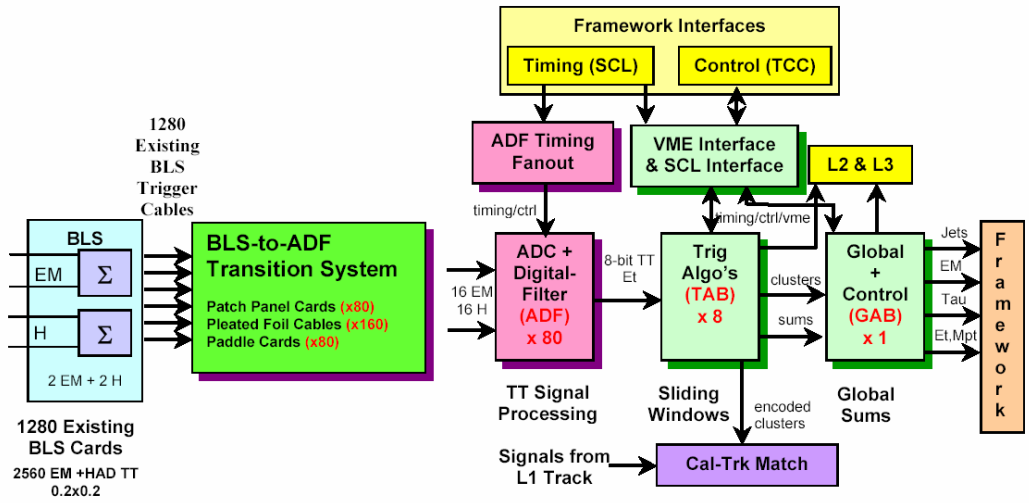
Inner radius for first sample reduced from 2.7 to 1.6 cm

Improved radiation tolerance

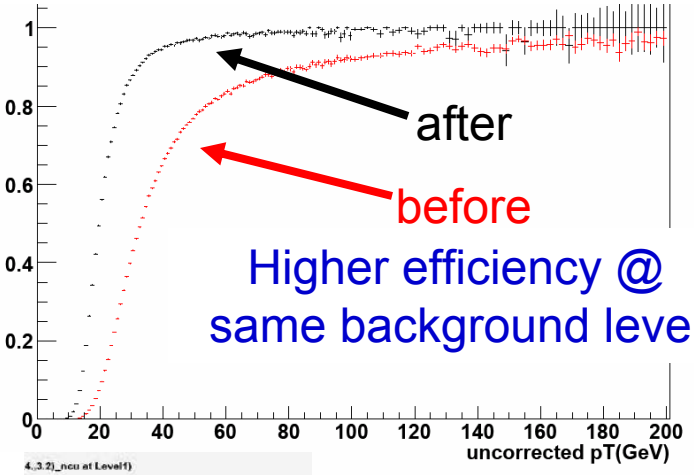
100% channels working!

Doubled our sensitivity for B_s oscillations

Calorimeter Trigger Upgrade



15 GeV Jet trigger turn on

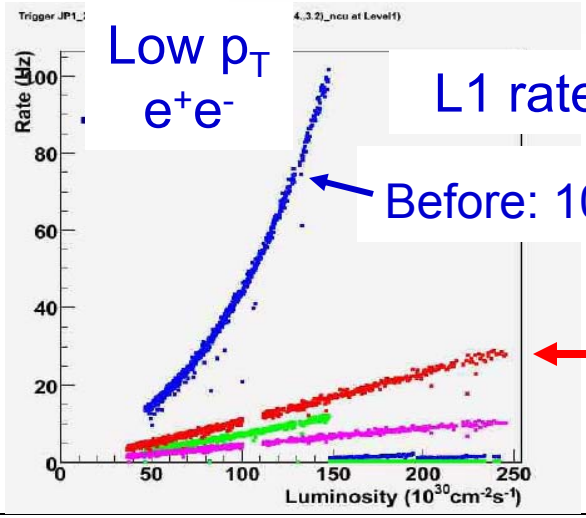


Higher efficiency @ same background level

Clustering, track matching, EM and tau ID at level 1

Allows stable running at all Tevatron Luminosities

Low p_T e^+e^-



L1 rate versus lum

Before: 100 Hz @ 150 e30

After: 30 Hz @ 250 e30

Further Tracking Upgrades

- New readout electronics
  - Eliminates amplifier saturation
  - Provides more stable pedestals and more uniform performance

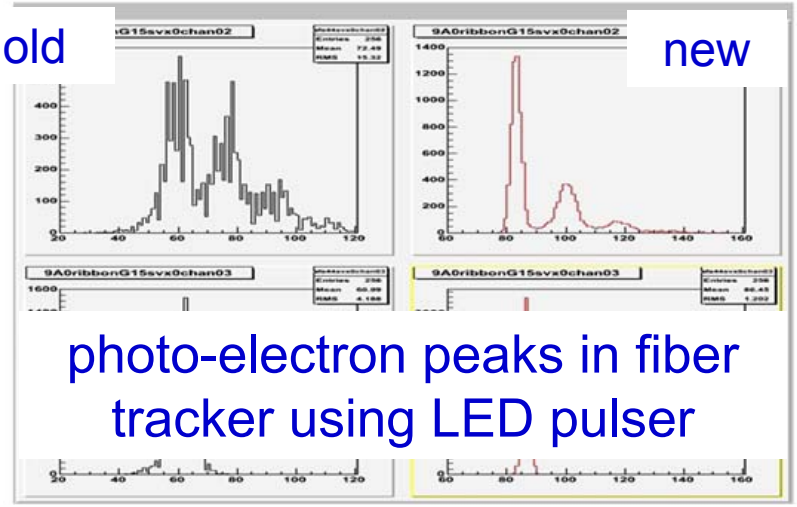
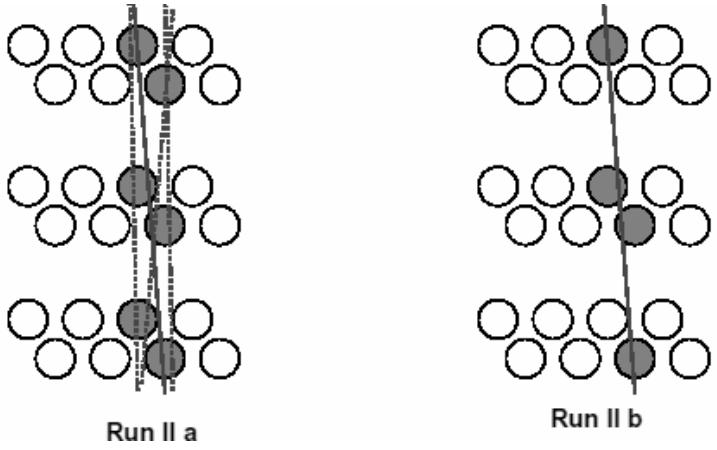
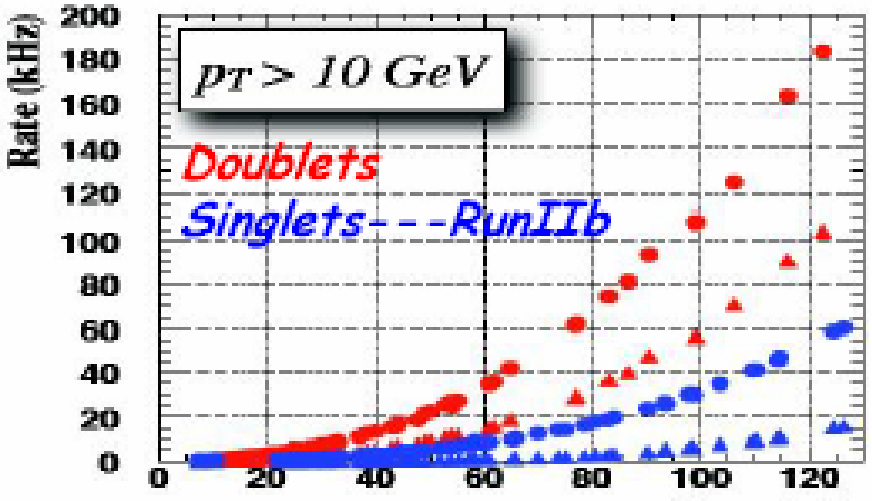


photo-electron peaks in fiber tracker using LED pulser

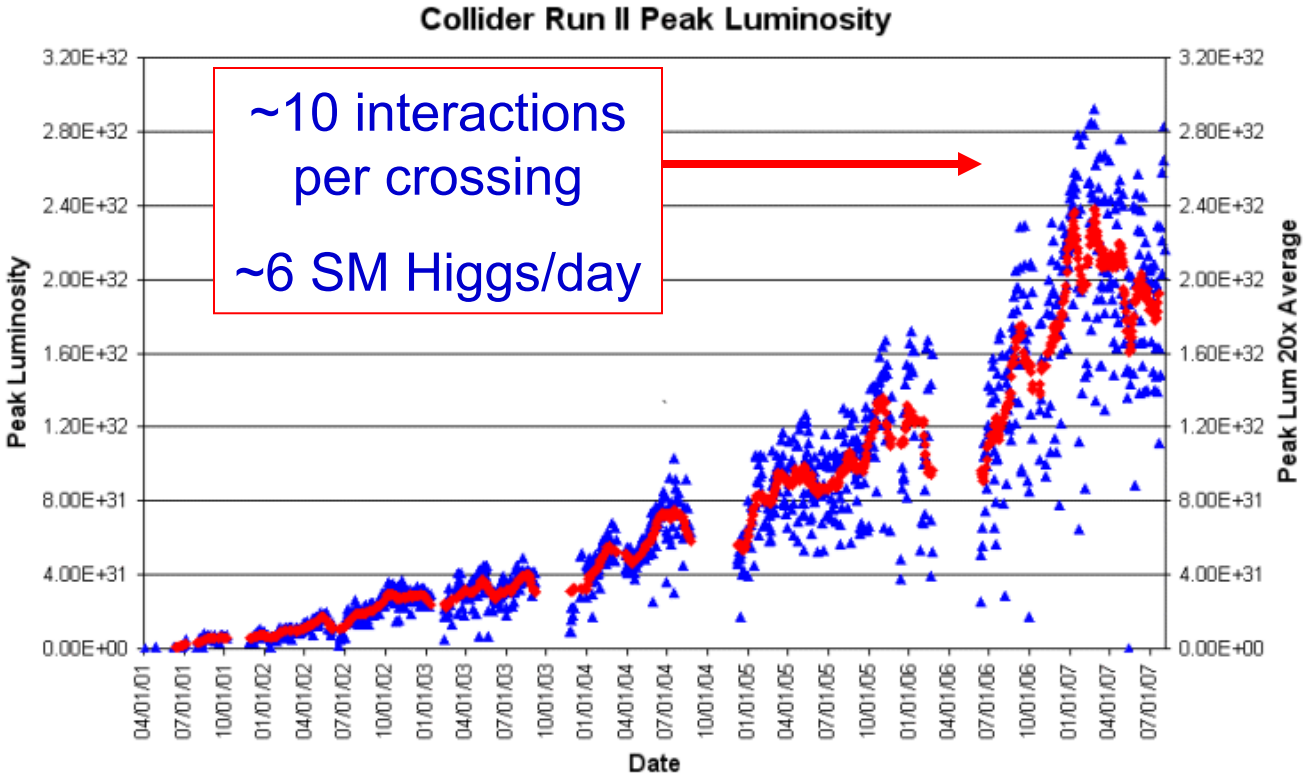
- Better trigger logic
  - Singlets versus doublets





Rate v lum for track trigger

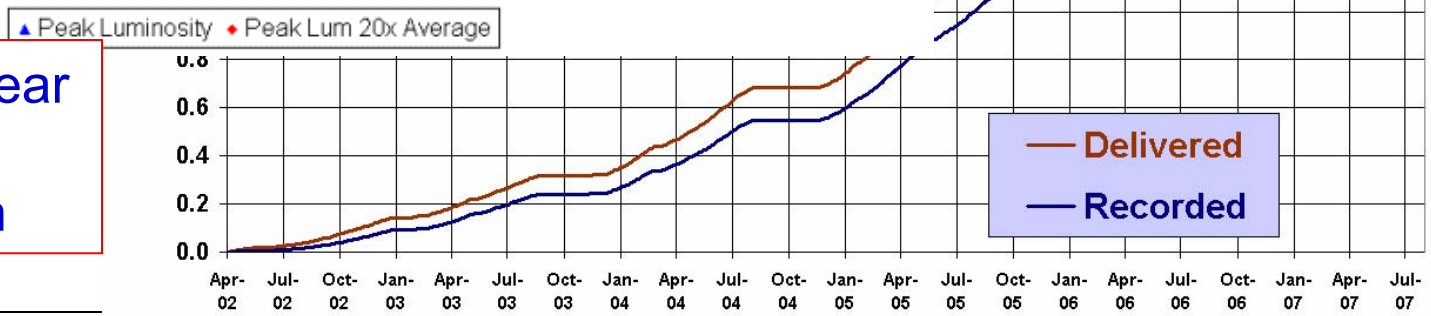
FY07 Luminosity



~10 interactions per crossing

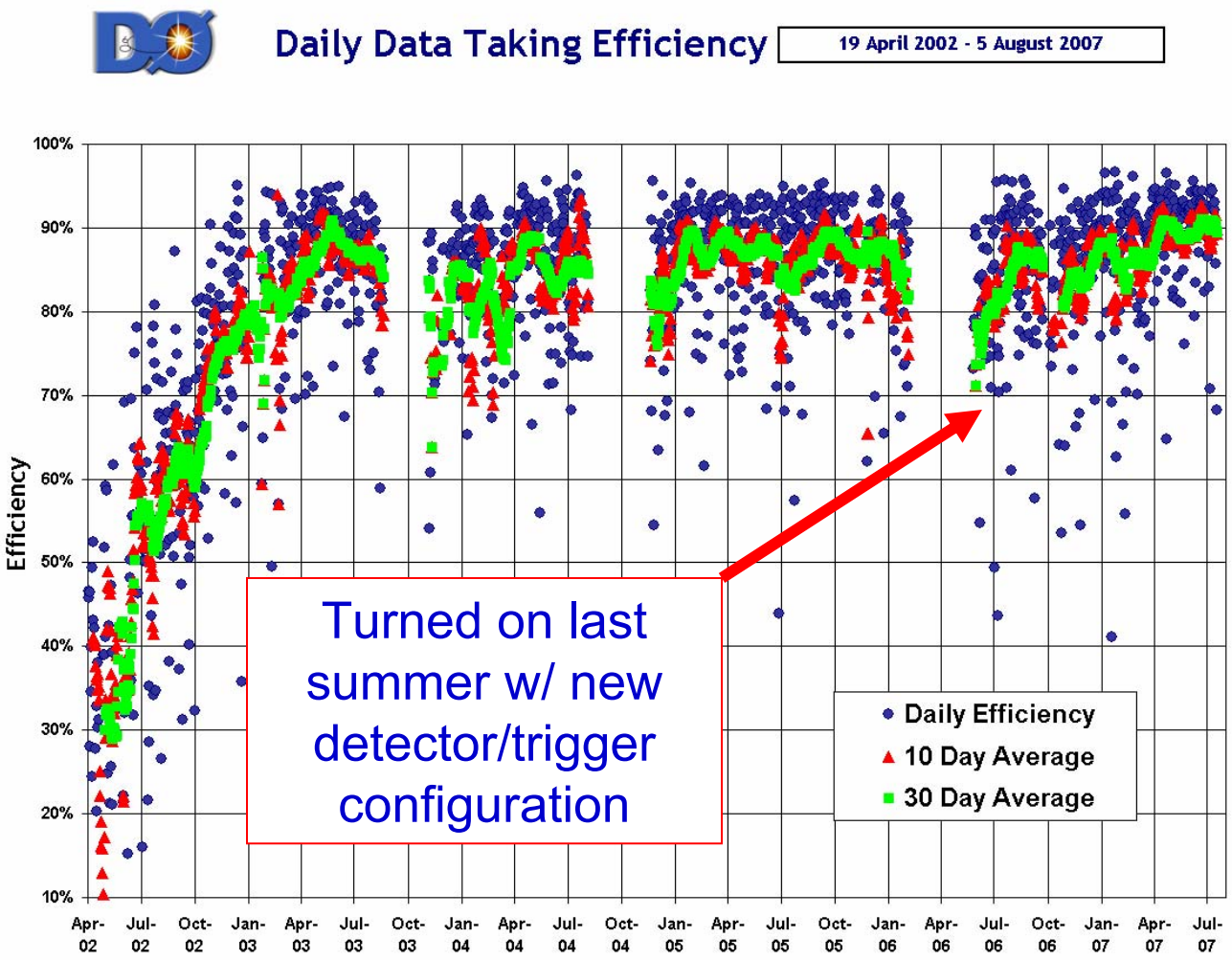
~6 SM Higgs/day

3.3 fb^{-1} delivered, 2.8 fb^{-1} recorded



Fantastic year for the Tevatron

Operations



~90% efficiency even at high luminosity

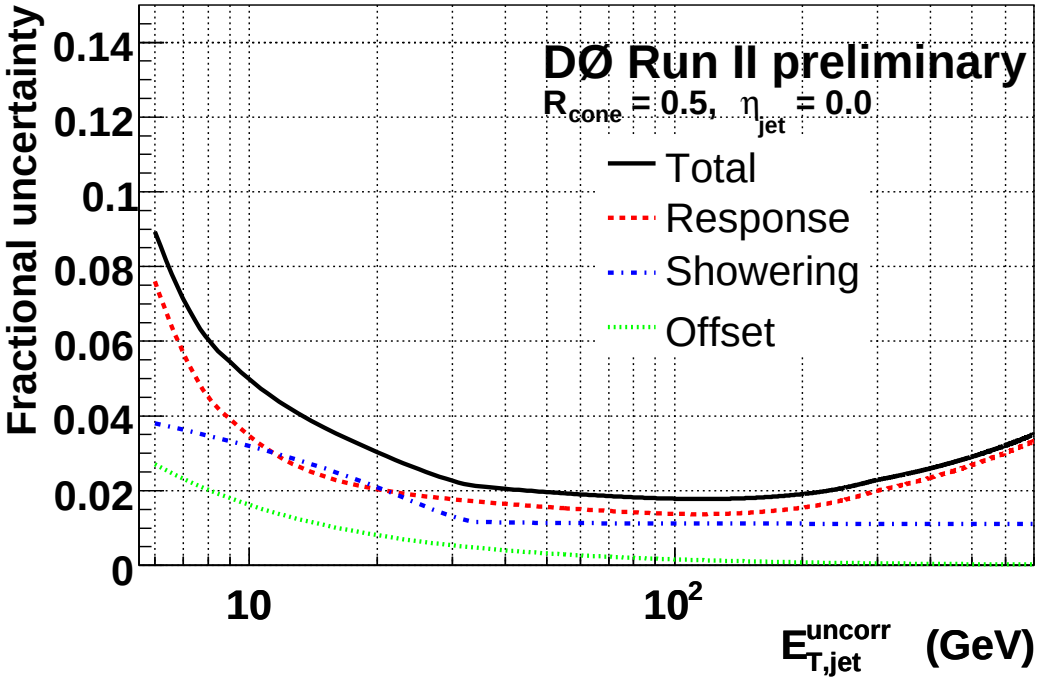
DØ adjusting and even improving with increased instantaneous luminosity

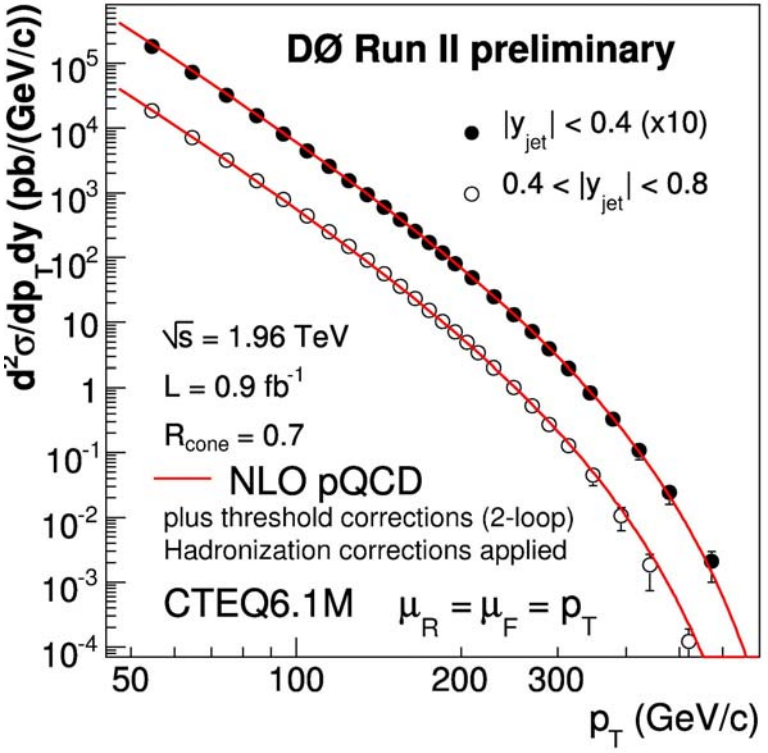
Physics Highlights

- Core measurements
  - Physics with jets, gauge bosons
- The third generation
  - Top, B physics
- New phenomena
  - Indirect and direct searches
- Higgs hunting
  - Low mass, high mass, non-SM

Core measurements

Major improvements to understanding of the jet energy scale and jet production

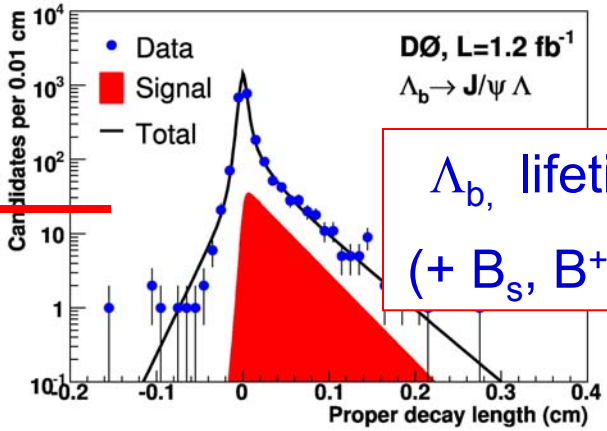




Third Generation weak couplings

Quark mixing matrix

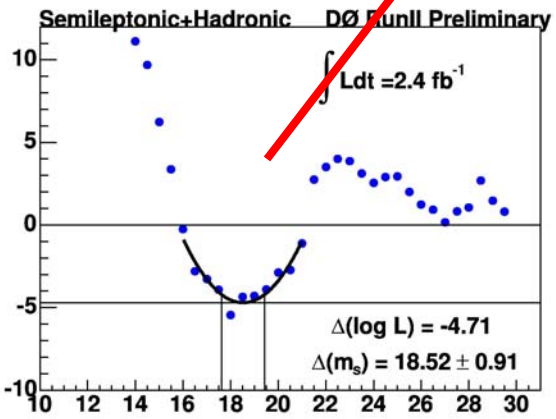
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

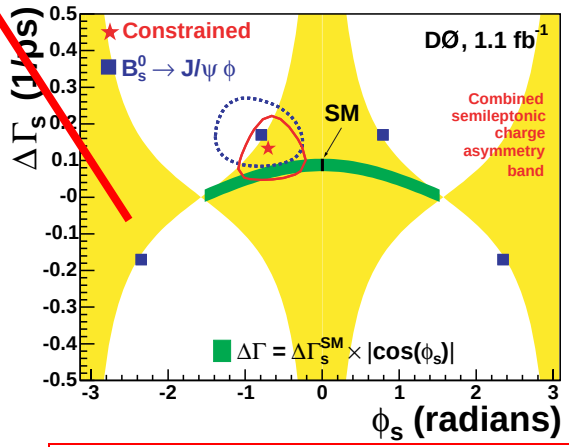


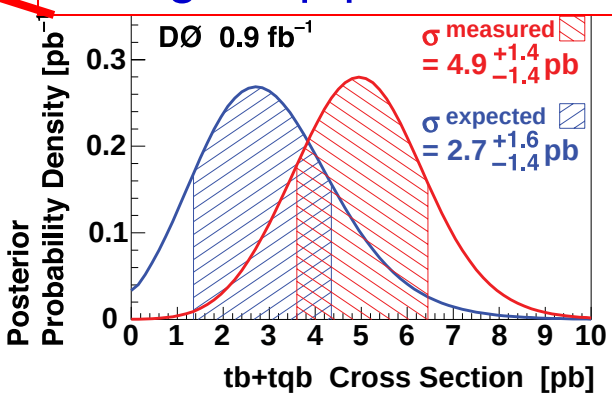
Λ_b lifetime

(+ B_s, B^+, B_d)

Single top production





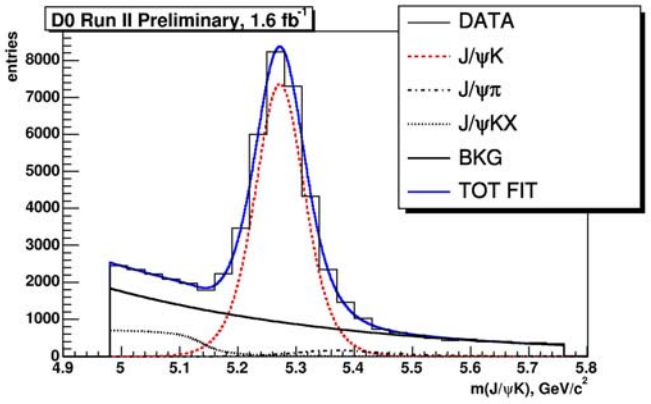


B_s (B_d) mixing amplitude

B_s (B_d) mixing phase

New particle/interaction searches

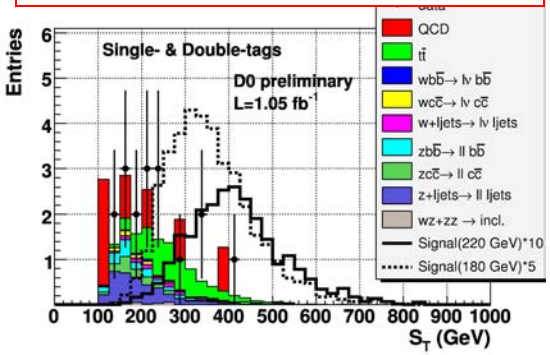
Indirect:



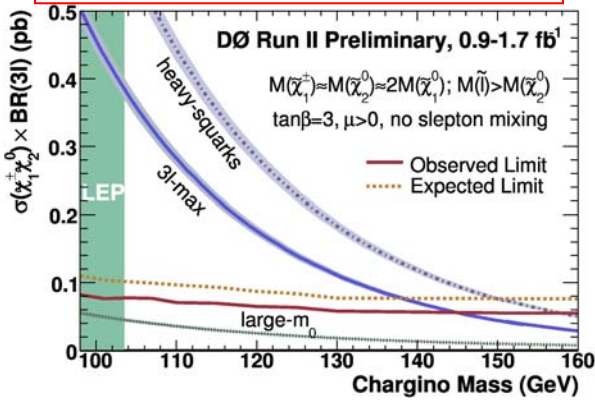
Precision DCPV in J/ψ K±

Direct:

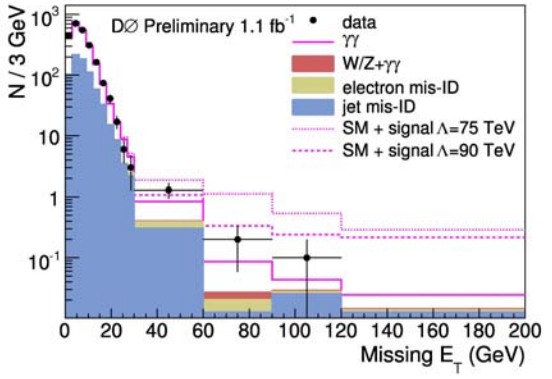
3rd gen. lepto-quarks



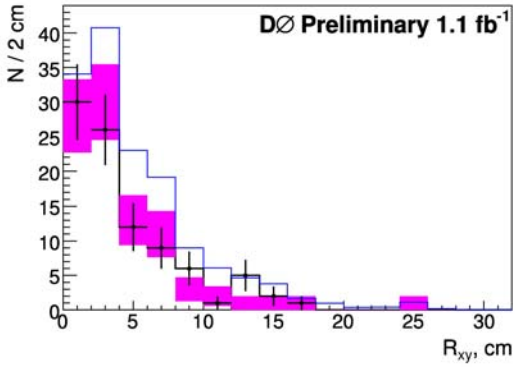
MSSM tri-leptons



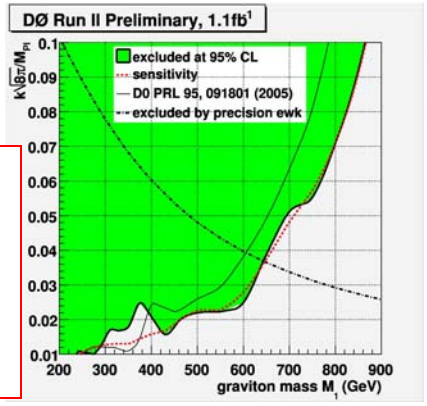
GMSB di-photons



Long lived massive particles

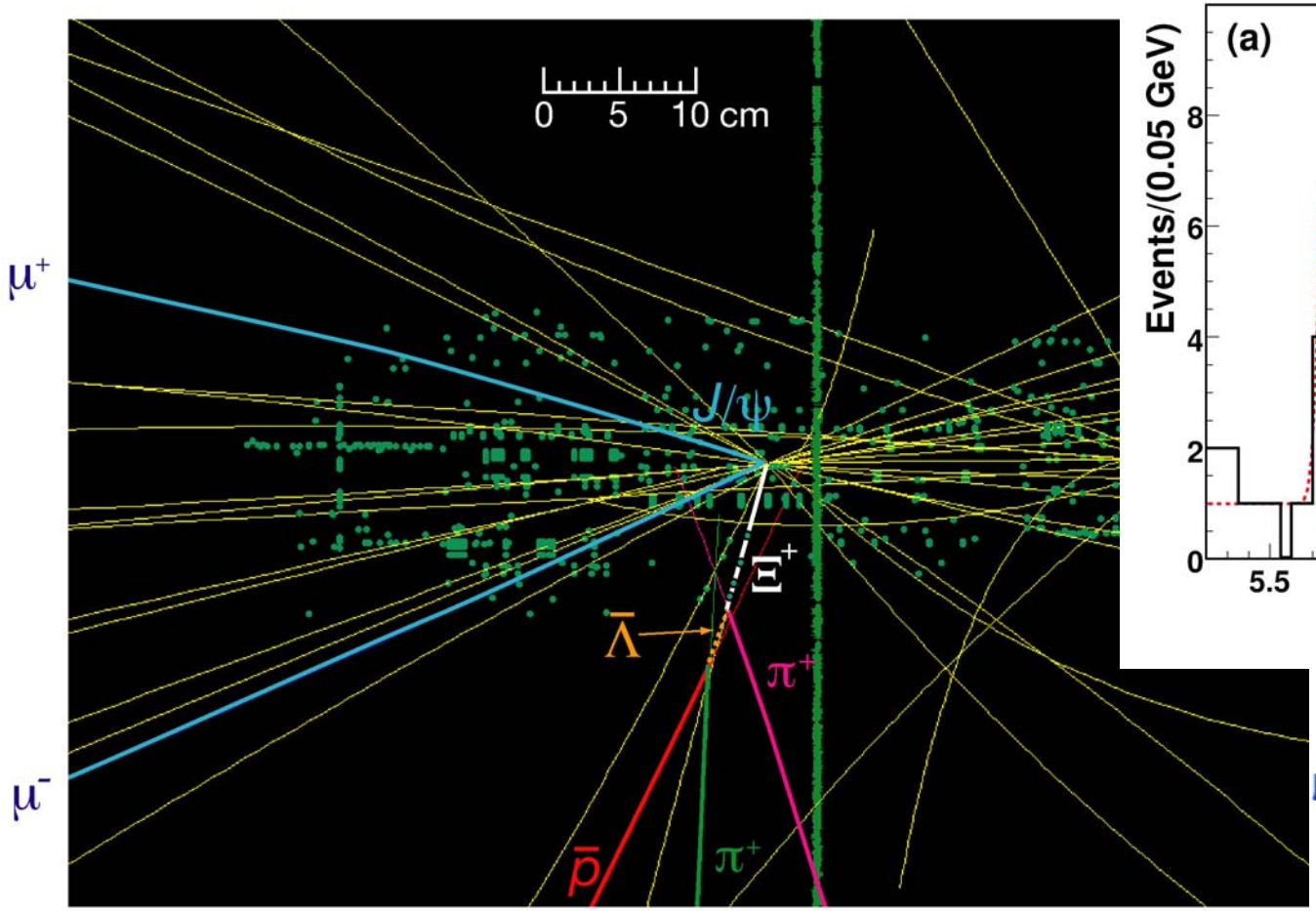


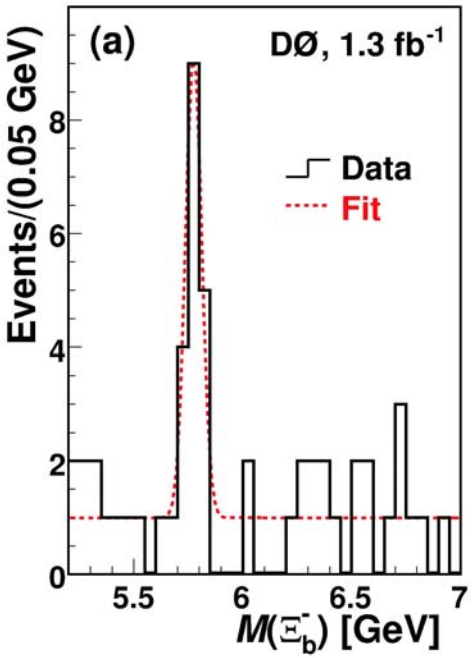
Extra dimensions RS gravitons

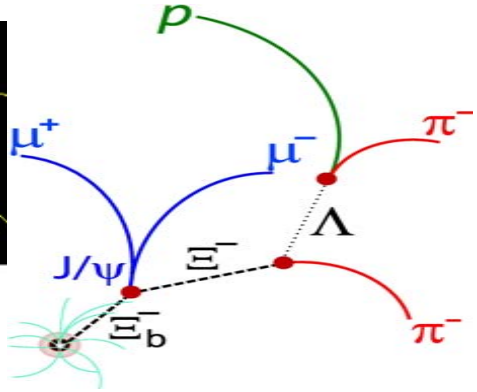


Many models, many regions of parameter space

New particle discoveries: Ξ_b^-



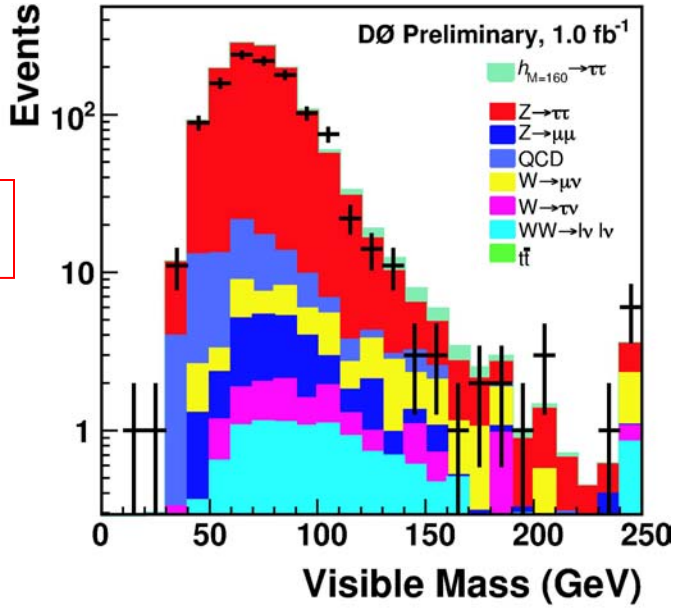


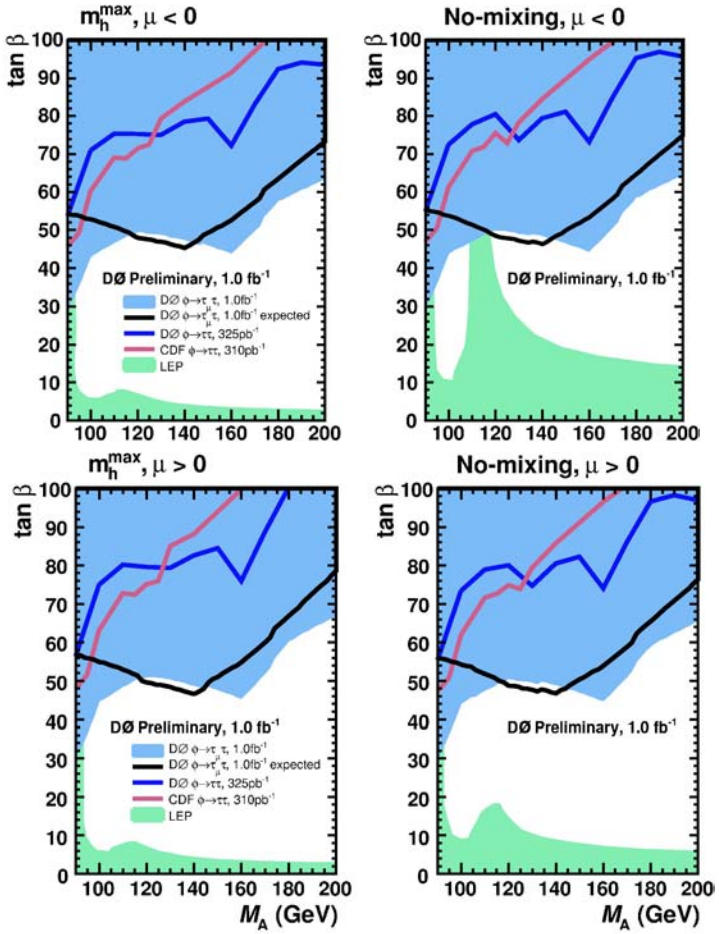


Run 179200, Event 55278820, $M(\Xi_b) = 5.788$ GeV

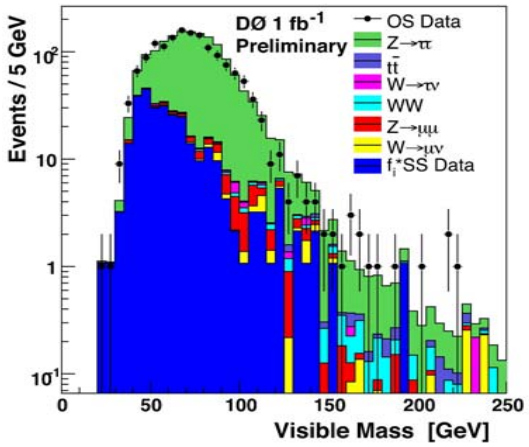
Direct searches for non-SM higgs

h/A/ϕ→ττ





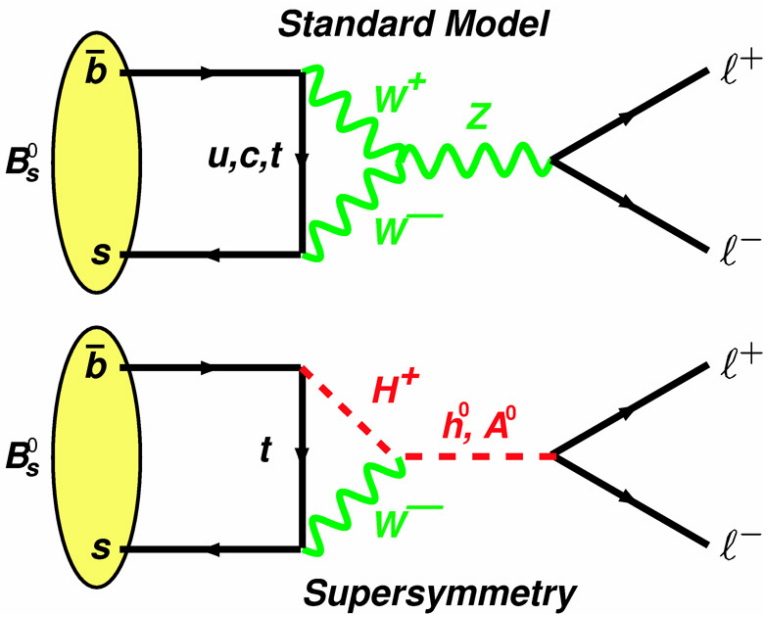
Benchmark with σ(Z) x BF(Z→ττ)



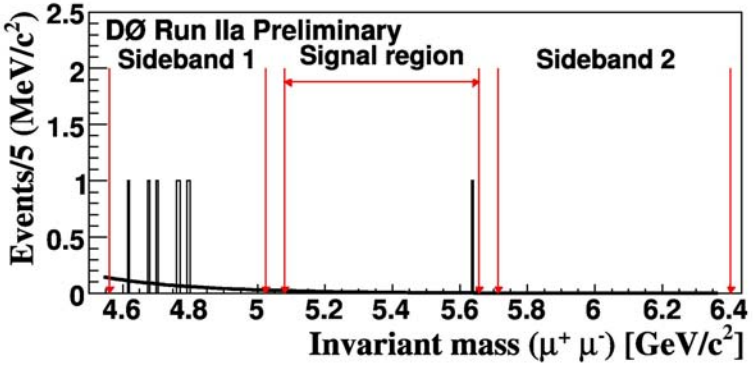
h/A/ϕ→ττ exclusions

Indirect searches for non-SM higgs

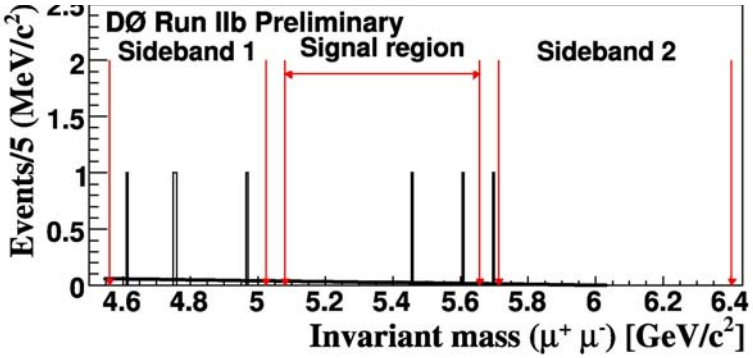
$B_s \rightarrow \mu\mu$



Data with original silicon



Data with new layer Ø



Rate limited to within factor of ~20 of Standard Model

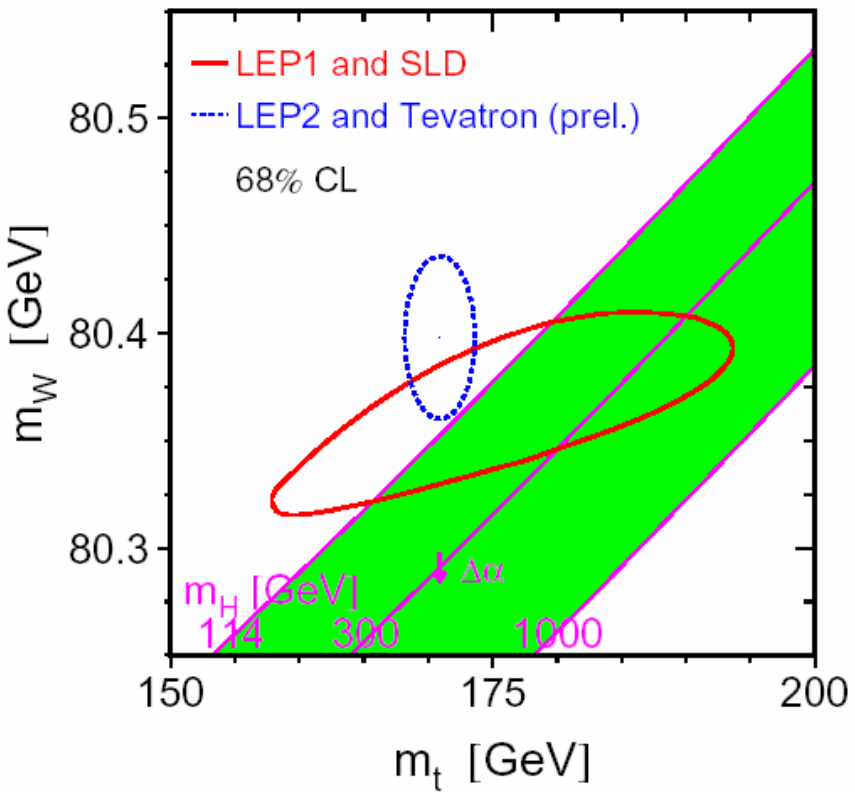
Installation to Conference

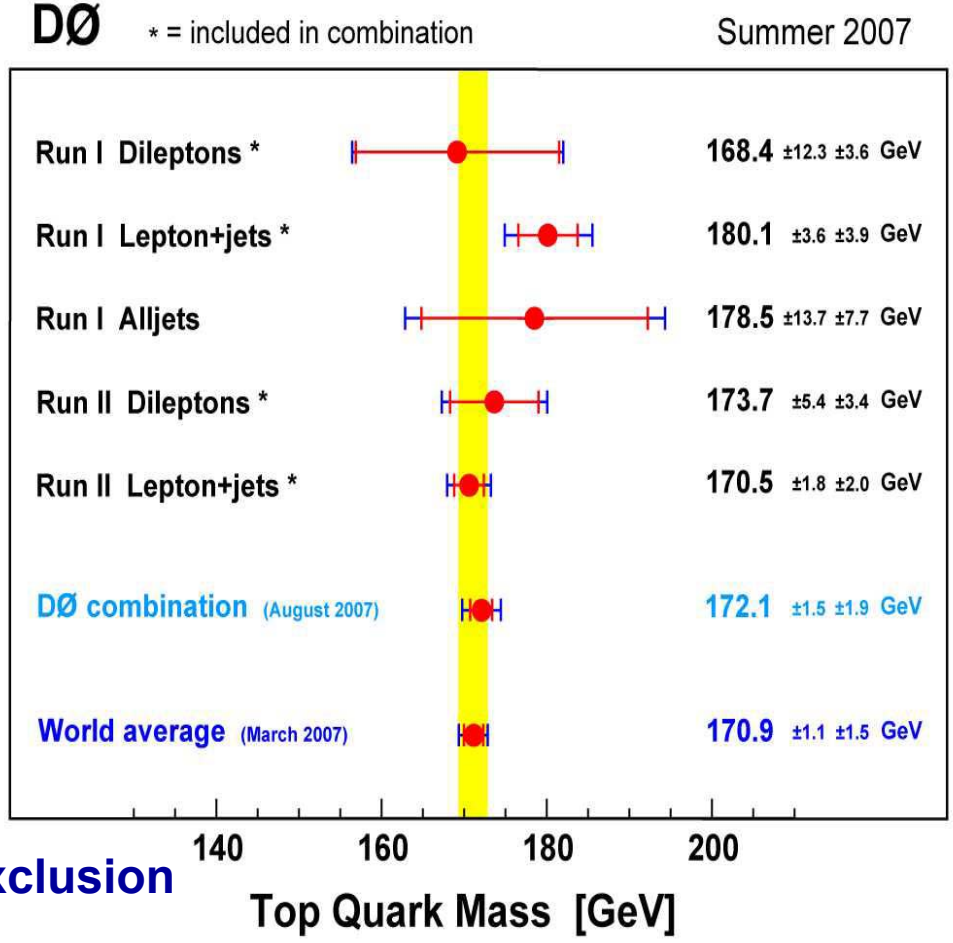
- April 16, 2006: Layer Ø installed inside DØ
- June 9, 2006: First data with Layer Ø
- February 1, 2007: Last run to make it into analysis
- March 16, 2007: 2 fb^{-1} $B_s \rightarrow \mu\mu$ result presented at Fermilab seminar / Moriond EW

Analysis frozen before data taking

Getting the result out this quickly is a direct product of the work of the commissioning, operations, and processing teams. In all cases, major participation from the Fermilab group

SM Higgs: Indirect info





M(H) < 144 GeV without LEP direct exclusion

M(H) < 182 GeV with LEP direct exclusion

(LEPEWWG)

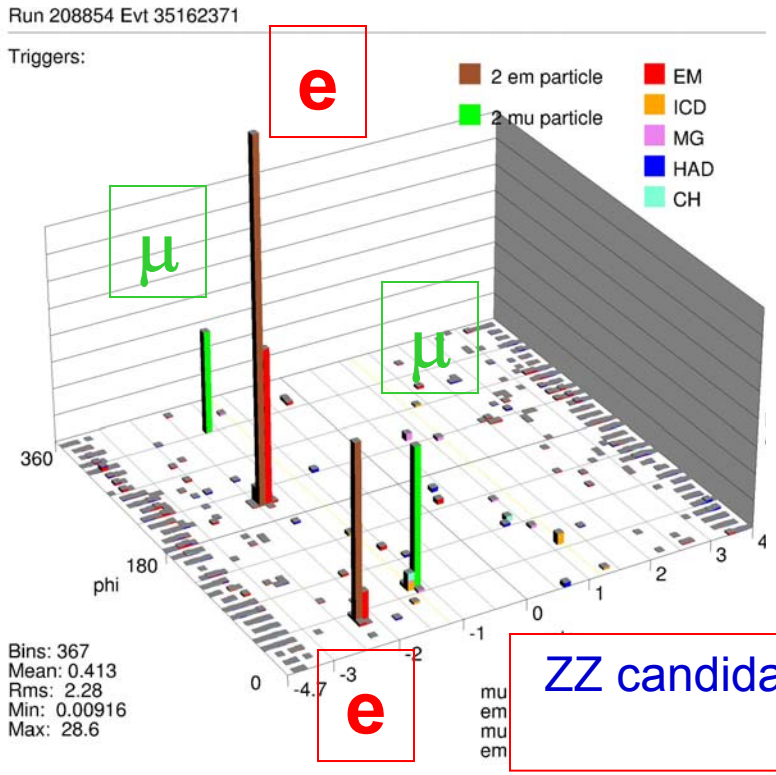
SM Higgs

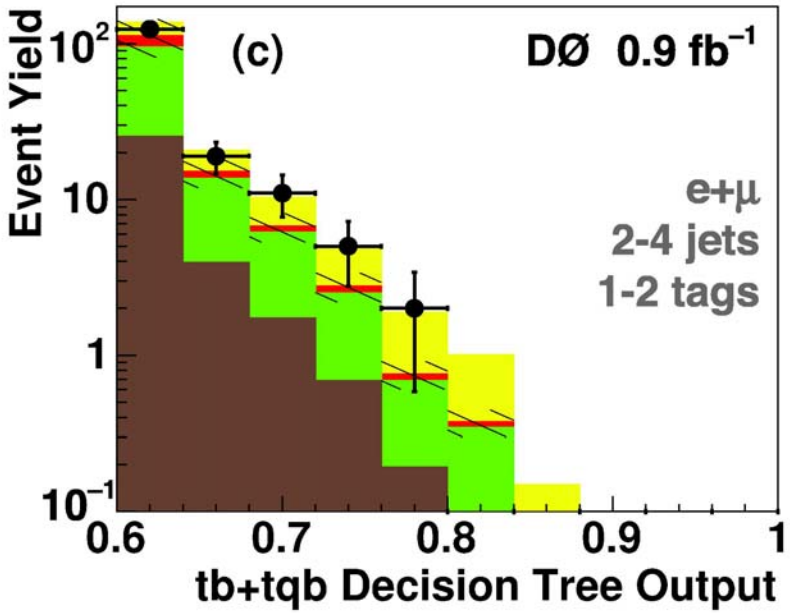
- Recent improvements:
  - More data
    - Summer results included ~full data set
  - More channels
    - Total now: 22 separate analyses
  - Expanded trigger selection
  - Better neural network based b tagging
  - Better neural network based signal extraction
    - Also implementing matrix element signal extraction
  - More information used in limit setting
    - Discriminator shapes, constraints from background dominated regions

SM Higgs Benchmarks

High mass:

Standard Model WW, WZ, and ZZ production



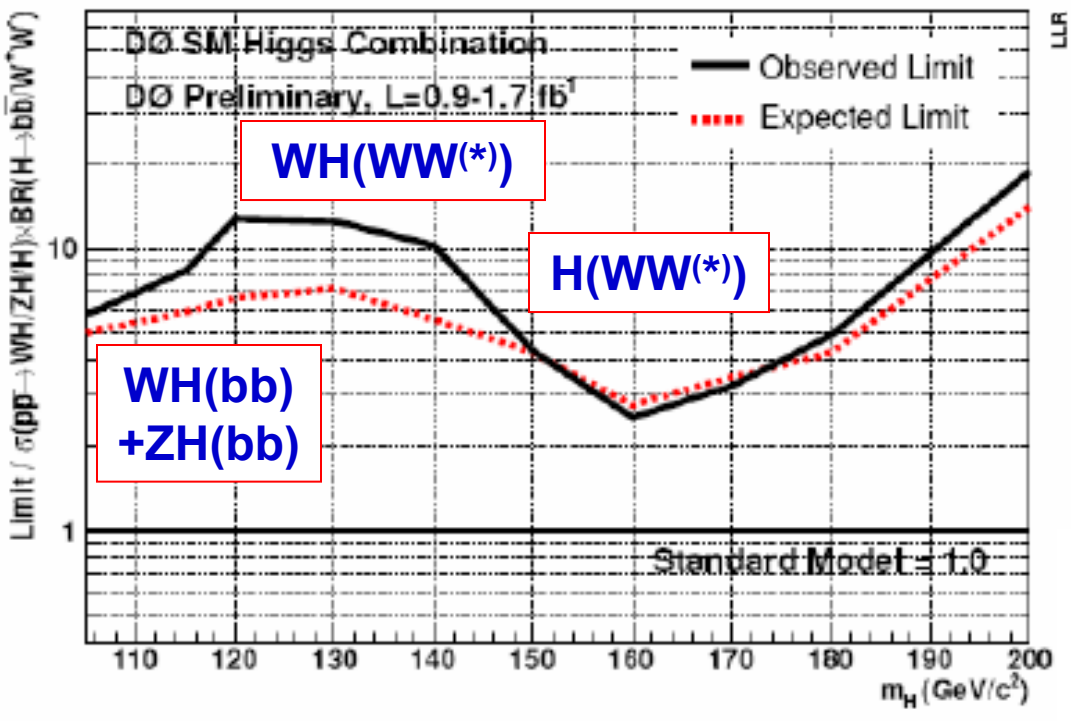


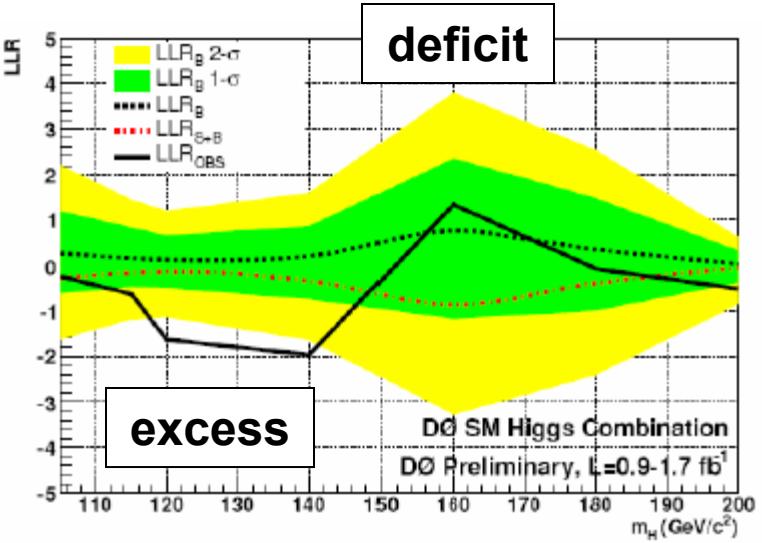
Low mass:

Single top production in Wbb channel

ZZ candidate event display in calorimeter $\phi-\eta$ projection

SM Higgs

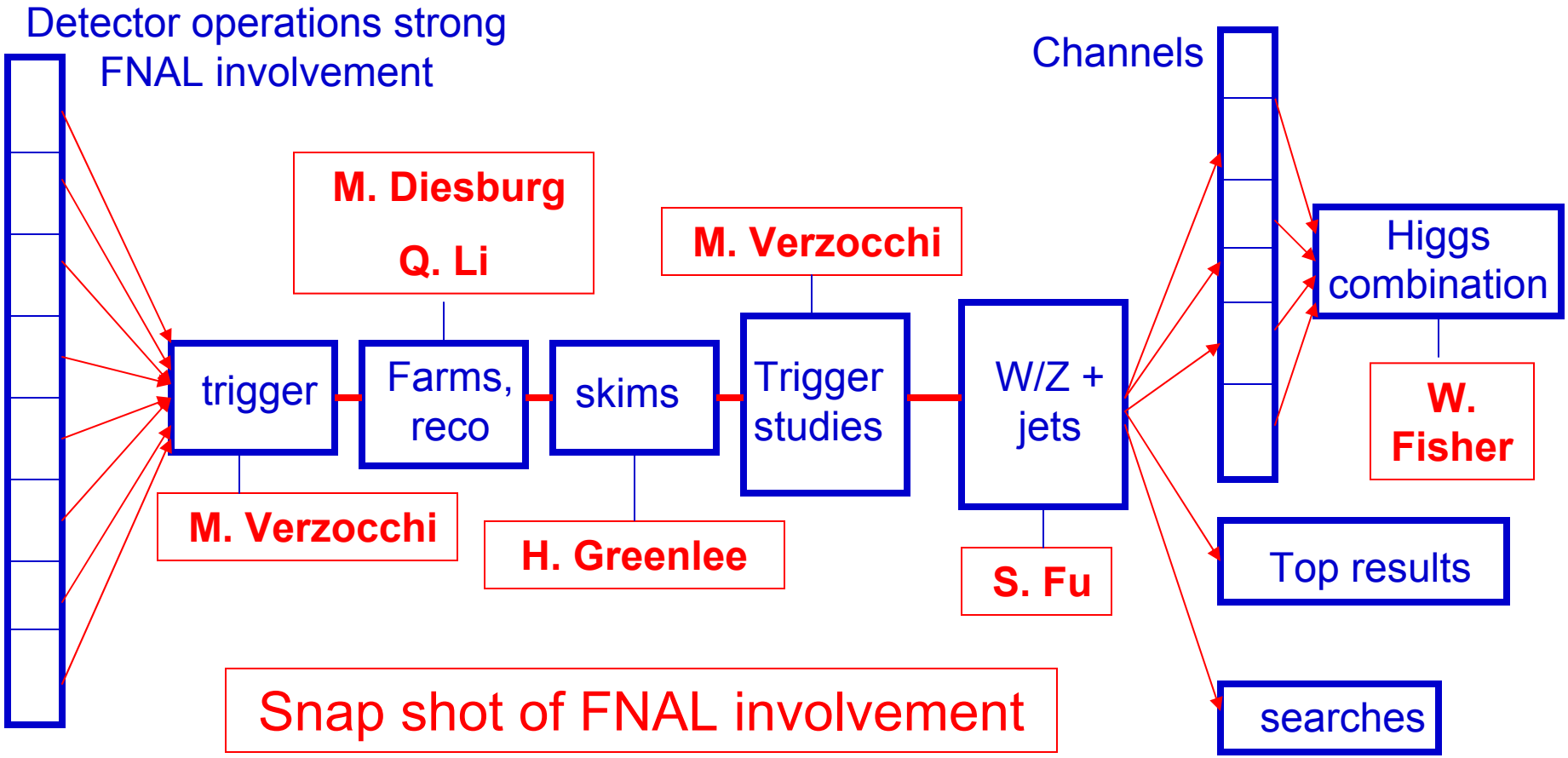




Shaded region = 1 and 2 σ width on background expectation

- Combination includes data taken up to May 2007
  - m(H) = 115 GeV: 6 x SM expected, 8.3 x SM observed
  - m(H) = 160 GeV: 2.8 x SM expected, 2.3 x SM observed

Road to Lepton Photon 07



Trigger studies: turn-ons, deadtime accounting for OR-ed trigger suites for all analyses

W/Z + jets: efficiencies and backgrounds for all samples in data and MC for all analyses

Tevatron 2010

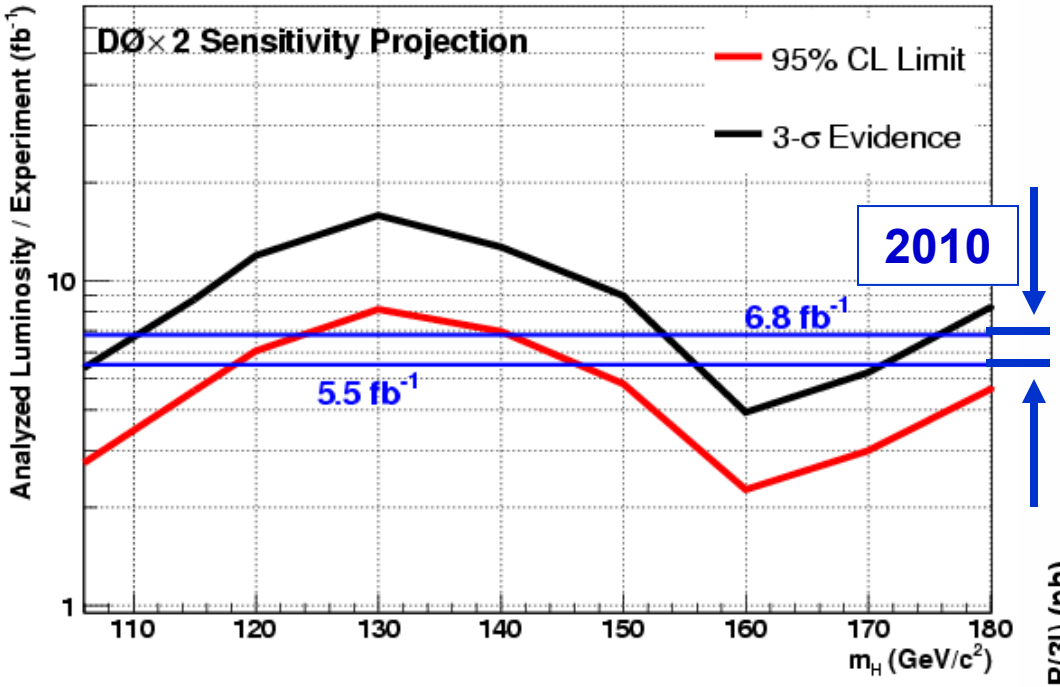
- Present diversity in our physics program gives us access to the several different possible manifestations of new physics at the Terascale

- We have the possibility to re optimize the detector configuration for targeted running.
  - This summer's rapid turn around of results demonstrates this is possible on a short time scale

- We are now working to keep the door open for possible extended running in FY2010 based on some of the most promising examples of possible discoveries
  - P5 meeting this week to discuss this option

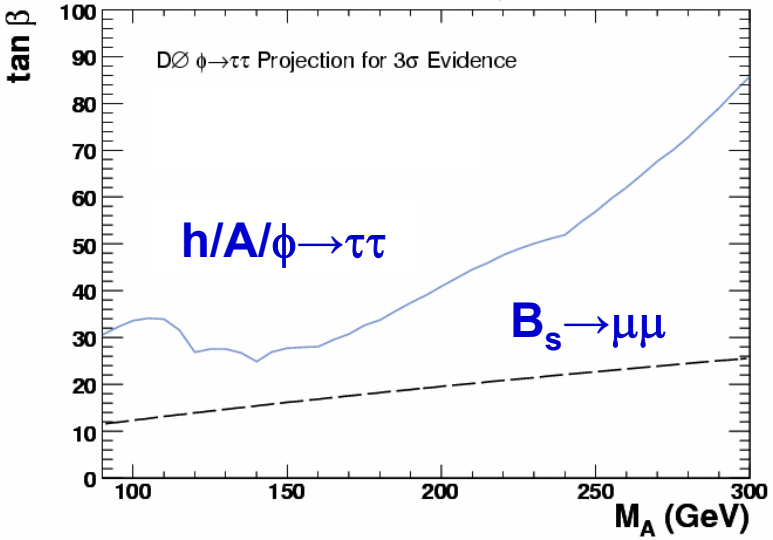
Tevatron 2010

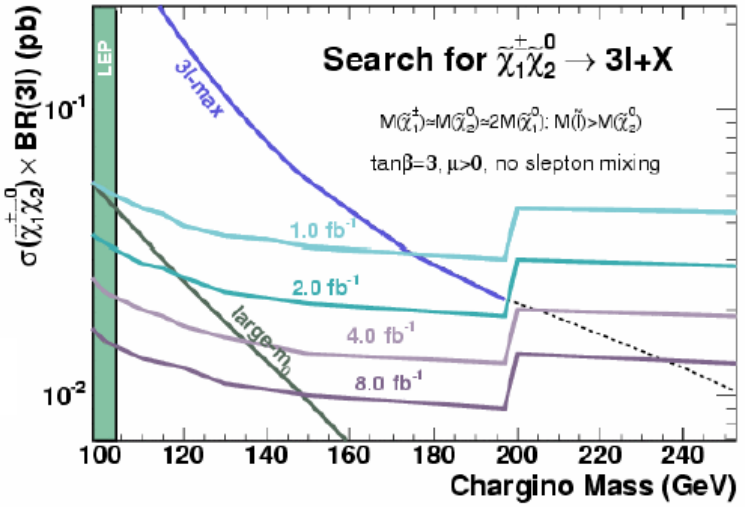
3 sigma Standard Model Higgs



3 sigma High tan β SUSY

Large mixing, small μ





all assuming 2 experiments input

tri-leptons for low tan β SUSY

assumes analyzed lum ~0.8 x delivered lum

Conclusions

- Amazing year of all around success for DØ
  - Detector/software performance
  - Quality and variety of physics results
  - Major contribution from the Fermilab group + supporting staff
- Improvements in performance leading to growing enthusiasm for our prospects for discovery with entire data set
  - Evident in ability to still attract new members to Fermilab group
- In most areas, still have not maxed out performance
  - Fertile ground for new ideas or extended running targeting specific physics goals